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ATTEMPTS TO USE RESEARCH BY STUDENTS AT PRE-GRADUATE LEVELS AS AN EDUCATIONAL TOOL IN THE BIOLOGICAL SCIENCES·

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I. INTRODUCTION

Sri Lankan traditions are still largely those of a feudal agricultural society, the capitalism grafted on it during the last century and a half being agricultural and introducing few changes that were not compatible with these traditions. (Moves towards industrialisation are relatively recent and limited). We have, therefore, an ethos in which working with one's hands is not merely something that can be tiring, it is also considered demeaning and desirable to avoid.

Another characteristic of our ethos is that the outdoors is disliked. This may possibly be related to the fact that there are more hazards in the biological environment of the tropics than in that of more temperate regions of the earth; but, largely, it has to do with the fact that the outdoors is the place where the 'lower' classes labour to produce the wealth of the feudal rich, a place associated with sweaty toil.

Yet another important traditional feature is the pervasive belief that Thought *alone* is sufficient to solve any problem, *provided* that the thinking is done in strict conformity with rigid, even rigorous, rules and rituals; Experimentation is *not needed at all* as an adjunct to Thought.

This belief leads naturally to another important traditional peculiarity, one which, in the early 1950's, I named the "Guru Complex." This is an unabashed reverence for and worship of the teacher, and an uncritical acceptance of all the teacher says, the excellent and oft-quoted admonition of the Lord Buddha, against accepting any teachings without critical examination, notwithstanding.

Now, all this can have and has had several undesirable consequences for the teaching of biology in Sri Lanka. For example : field classes are neglected; laboratory work in schools is often skimped, even eliminated; students quite uncritically mug up masses of lecture and textbook notes and graduate, some with excellent classes, to become 'walking encyclopaedias', full of the soundest theory but quite lacking in the self-confidence necessary to tackle problems on their own, and needing to rush for advice to foreign 'experts' here and abroad.

Such biologists perfectly fit the requirements of the ever-paternal, neo-colonial, 'aid-givers' to the poverty-stricken Third World; and they find great favour in the eyes of an ex-colony's leaders and administrators. Nevertheless, they can do little, really, to help our country forward[1]; and I have tried persistently and in various ways to break this diffident, theory-dominated mentality and put a healthier self-reliant attitude in its place. Of these attempts I shall, in this article, give accounts of those three[2] in which I sought to use research by pre-graduate students as an educational tool — two of them at the university and the third in schools.

II. (1) THE UNGUIDED RESEARCH PROJECT

This was devised and introduced by me into the curriculum of the B.Sc. (General) degree of Vidyodaya (now Sri Jayewardenepura) University about 1966-67.

Every biology undergraduate, within a month of his[3] first entering Vidyodaya, is assigned a research problem, which is ecological and centred on some feature of the natural habitat near his home. The following are a few examples of problems that have already been set :—

(*a*) An ecological study of the fauna and flora of rock-cuttings along the Kadugannawa-Rambukkana railroad.

(*b*) Behaviour, with particular reference to web-building, of the garden spider, *Gasteracanthus*.

(*c*) Biology and economics of the 'Mechanised Boat' Fishery off Mirissa.

(*d*) Ecology of the fresh-water crab, *Paratelphusa*, in a stretch of paddy-fields near Horana.

(*e*) A study of the distribution of Brown Sea-weeds (Phaeophyceae) around Sri Lanka, and of what factors might control it.

(*f*) Biology and economics of banana cultivation in villages around Rambukkana.

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1. For a more complete discussion of some traditional and more recent components of our ethos and of their effects on education, especially in the biological sciences, see : Weerekoon, A. C. J. "The Environment of Biology Teaching in Sri Lanka", *Bionews*, (in press), published by Institute of Biology, Sri Lanka.
2. Accounts of the first two formed the main part of a lecture on "The Use of Research for Science Education at Pre-graduate (University) Levels" delivered by me on 25.11.1983 at a meeting organised by the General Research Council of the Sri Lanka Association for the Advancement of Science (SLAAS). The third (Hydrobiological Survey of the Thondaimannar Lagoon) formed the first part of a lecture on "Some Innovations of a Biologist" delivered by me on 13.12.1983 at the Seminar on 'Science Education' organised by the SLAAS for its 39th Annaual Session. (The second part of that lecture has been published in the *Vidyodaya J. Arts, Sci., and Lett.*, *Vol.* 12, *pp.* 480-489, 1984, with the title "Glimpses of the Making of the Vidyodaya Science Faculty, 1965-1971.")
3. The masculine pronoun is used here, and elsewhere in this paper, for both males and females.

Research problems of this sort force students out of doors, to work on them. A student is expected to do this field-work during the university vacations and during any week-ends he may be able to spend at home; and to do the connected laboratory work during his free periods in term, so also any library reference work.

With the Research Project spread over the 3 years of his degree course the student has ample time — time to plan the work himself, to correct false starts, to repeat and verify, and finally to produce the Report[4], a substantial one, which he is required to submit by a specified date about one month before his Final Examinations. Each Project Report is scrutinised by the entire Board of (degree) Examiners, but in special detail by 2 of them assigned to it; and the student faces, during his Finals, a searching Viva Examination on his Report. In other words, he is required to 'defend' his thesis before a formal Board of Examiners which thereafter awards marks, the Viva and the Project Report counting as equivalent to one of the series of Practical Examinations forming part of the Finals.

B.Sc. (Special) Botany or Zoology undergraduates of some of the other universities in Sri Lanka were *sometimes* required to work at a small research problem during the 4th year of their course. But this Research Project which I devised for Vidyodaya differed from that scheme in several essential ways, namely :

(*a*) Whereas the B.Sc. (Special) undergraduate was guided in his research by a Supervisor, this Vidyodaya Project is a piece of *unguided* research. In it the student is required to tackle the problem on his own, using his own initiatives and without guidance from any of his teachers. He is welcome, of course, to discuss *his* ideas and *his* proposed lines of attack with any teacher; and the teacher is free to comment, but he is specifically instructed *not* to guide the student's efforts, not even to discourage any course of action proposed by the student which the teacher feels is valueless or incorrect. A teacher may, on request, assist the student to procure some particular chemical or piece of standard equipment (like pH-meter or microtome) which the student feels he needs; he may even assist the student with mastering some new technique which the student has himself decided to use. But he may not decide for the student what chemical, equipment or technique he should use, nor help him devise or build any special piece of equipment the student feels he needs (for estimating speed of water- currents, or height of trees or population density of some animal, or diurnal variation in its activity, for example).

4. Several Project Reports, from past years, were on view at the November 1983 lecture. Persons wishing to inspect such Project Reports now should apply for permission to: Head, Zoology Department, Sri Jayewardenepura University, Nugegoda.

(*b*) The Vidyodaya Project problem is ecological and ensures that the student moves out of doors for his observations and collections.

(*c*) This Project is for the biology undergraduates of the *B.Sc.* (*General*) *course* at Vidyodaya and has to be done by *all* of them; it is not confined to the handful of undergraduates who are selected for the Special course[5] each year.

(*d*) Our student has more than $2\frac{1}{2}$ years for his research, instead of the mere 6-7 months available to the B.Sc. (Special) student.

(*e*) Our student, at the end of his Unguided Research Project, is subjected to a searching Viva Voce examination of his research attempts, his conclusions and his Report. The mere carrying out of instructions which may be given him by parents, friends and other such 'helpers' will gain him nothing at the examinations, however impressive his Report may seem at first sight.

(*f*) Our student is given more credit for the way he sets about his work and tackles difficulties, for originality and ingenuity, than for neat answers and solutions.

In the many years since the introduction of this device some defects have surfaced and the scheme has been amended to counter them. One of these defects has been a tendency of some few students to fudge results and observations, despite our repeated assurances at the problem-assignment sessions that detection is very easy at the Viva and will result in a heavy loss of marks. This penalty is steadily driving home the lesson that this traditional 'originality and ingenuity' is not the sort the Unguided Research Project seeks to encourage. Fortunately a growing number of students seems to realise that the whole exercise is for their benefit and that honest work, even if awarded low marks because of poor standard, brings other and more valuable rewards.

Another defect was a tendency amongst students to put off the work till late in their course; for example, till the end of the 2nd academic year. This was countered by getting each of the students to deliver a brief 15-minute interim oral report on work done on his problem at special weekly meetings of fellow students (who were required to question and comment) and academic staff, beginning at the end of the first Long-Vacation. At each meeting 2 or 3 students reported, separately; students being told that they would be marked on their presentations and these marks taken into consideration at the Viva.

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5. Since at Vidyodaya students are selected to study for the B.Sc. (Special) degree from amongst those only who have completed sufficiently well the B.Sc. (General) examinations, it follows that B.Sc. (Special) graduates of Vidyodaya have already been through the training of this Unguided Research Project before they begin the guided research of their 4th or Special year.

A different kind of difficulty is that this Viva examination has grown with increase in numbers of students, into a very time-consuming exercise for the academic staff. It takes about $\frac{3}{4}$ to $1\frac{1}{4}$ hours to deal with just one student at the Viva, 6 to 9 at most during a day. As a result the Vivas *alone* take well over a week of the university's so-called Long Vacation, now almost completely filled, for academic staff, with work on a multitude of examinations. This difficulty has not yet been solved. Division of the Board of Viva examiners into several simultaneously functioning sub-boards, and standardisation of their marks, may be the way out.

II. (2) THE INVESTIGATION[6]

This second device by which I sought to use research by pre-graduate students of biology for education at university level was also introduced about 1966-67.

An undergraduate studying zoology for a B.Sc. (General) degree at other universities has to dissect about 2 dozen different kinds of animals, ranging from round-worm to cuttle-fish and from hag-fish to rat; he must carefully follow dissection guides (books or notes) when opening one of them up to display any particular organ-system; and he must then draw and label his dissection of these organs according to the labelled diagrams of the guide. Because of cost and/or difficulty of procuring specimens and because of the limited time that can be spared during the course for dissection of any one species of the 2 dozen which require to be done, the number of specimens of any one species that can be given to each student for making his dissections is also limited. He is, therefore, generally fearful that some slip of his —like the tearing of a blood-vessel or the cutting of a nerve—may damage the specimen and spoil his chance of learning how to make and study that particular dissection; a result which is, unfortunately, quite common.

Instead of all this I decided to get our students at Vidyodaya to dissect *just one species* of animal, *one for which no dissection guides would be available*, one which it would be easy and cheap for us to procure so that the student could have as many specimens of it as he wished and plenty of time to dissect them. There would be no constraint on his perfecting his dissecting skills.

The animal I chose was *Tilapia*, a fish which we were then able to buy at 10 cents a large specimen (about 10" long) any morning from the commercial fishermen operating on the Beira Lake, and supply fresh to our students. They were given no notes on its structure, nor were guides available[7]. Each student was expected to investigate it as the pioneers of our science, like T. H. Huxley or Graham Kerr, would have investigated some animal new

6. See Footnote 2.
7. Unfortunately, one may soon be published. When it is, another animal will have to be chosen for this Investigation.

to science. He was required to make a step-by-step study of the entire *Tilapia*, starting from its surface and moving inwards. As he came across organs and tissues about the nature of which he was uncertain — a patch of colour for example, or a scale, or a ribbon-like body which might be fat-body or testis — he was expected to discover its nature for himself, using microtome and microscope where necessary; teachers in the laboratory would refuse to tell him its nature, but would help him master any special techinques needed to investigate the unknown structure — e.g. special staining, or section cutting and so on.

As our student proceeded with this gradual, unhurried, and thorough investigation he was required to record his findings, with notes and labelled drawings. The teachers examined these regularly and marked them wrong, when necessary, but did not otherwise correct; the student was required to find out for himself what exactly was wrong and make his own corrections — he had ample time in which to do so, and as many more specimens of the *Tilapia* as he wanted.

Incidentally, when studying the skeletal system of this fish he was also required to make a properly labelled and displayed *Museum Preparation*[8] of the *Tilapia* skull. This was the only part of the exersice where some instruction was given on the animal. Each year, I demonstrated to the class of students how best to detach these delicate bones whilst establishing and recording their exact shape and position in the fish's head; and I also explained to them the principle to be followed in learning to distinguish the left from the right bone of a pair. At the Viva examination of his unguided research Project Report, five different skull-bones, each hidden from view in a separate container, were placed before the student and he was required to pick out one at random, examine and name it, stating also whether it came from the left or the right side of the skull or from its median plane. It is significant and gratifying that he was very seldom mistaken in his answer.

Besides this test the student was also required, at another practical examination in the series making up his Finals, to make a dissection of an animal; not *Tilapia* but *any other* animal which we, examiners, with all due secrecy, found it convenient to obtain and decided on, on the morning of that practical examination. It might be a chicken, water-snake, star-fish, crab or garden-lizard — in fact almost any animal other than a bony fish. The student was required to dissect whatever animal was placed before him, display, draw and label its internal organs as completely as possible, or flag-label certain specified structures.

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8. Two of these, prepared and submitted by students at past examinations, were on view at my November 1983 lecture. Persons wishing now to see examples of such Museum Preparations will find them in the Departmental Museum. Prior permission should be obtained from the Head, Department of Botany, Sri Jayawardenepura University, Nugegoda.

The calm assurance with which the student faced this test was itself a measure of the success of the Investigation as a device not merely for training dissection skills but also for inculcating self-reliance and confidence. Naturally he made some mistakes but, considering that he had never dissected the test-animal before, his performance was generally very creditable, his mistakes few.

As I had originally envisaged this device, the Investigation, not only the structure of the *Tilapia* but also something of its behaviour and functioning (for example, reproductive and courting behaviour, feeding and digestive, respiratory) would have to be investigated by the student; which meant at least one laboratory aquarium per student to keep his fish alive in. And I also wanted a similar investigation to be made of some suitable plant. But there were severe constraints of various sorts which brought these plans to nought. For example : a lack of funds for the many aquaria, aerators, microtomes and wax-baths (or ovens) needed, for simple physiological equipment, and for the nessary minimum of staff. So that the Investigation, as it did develop, came to be mainly one of the animal's structure, together with some tentative attempts at extending it to some plant structures and functions. Its value is bound to be greatly increased once the present imbalances have been overcome.

II. (3) HYDROBIOLOGICAL SURVEY OF THONDAIMANNAR LAGOON[9]

Early in 1959, I happened to be on a lecture tour of schools in the Jaffna Peninsula. Soon after my arrival there I found myself travelling towards Point Pedro, on my way to one of the schools I was to lecture at; I was being driven in his car by one of the teachers.

Talking to him about his work I asked whether he took his students into the field; for example, to the coral reefs off Point Pedro. He said he did, but added immediately that field-classes were boring. This seemed to confirm what I had often said, even then, of teachers and students in this country — for most of them an animal or plant was of no interest till it was dead and laid out for dissection, or cut into thin alices for examination through the microscope. But now I made no comment to my host about this.

As we approached the Thondaimannar Lagoon he told me about the barrage that had been built, six years earlier, by the Irrigation Department across the lagoon-mouth to exclude sea-water. A fresh-water lake running down the length of the peninsula would benefit farmers but the lagoon fishermen feared for their livelihood, he said. Our road soon took us away from the lagoon and our discussion of this conflict of interests changed to other matters.

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9. See Footnote 2.

In the course of 3 days of lecturing at about a dozen schools, I met and talked to biology teachers from around the Peninsula. Many of them seemed to find teaching dull and unsatisfying. I suggested that they inject interest into their subject by taking up a small ecological problem each, for investigation. Several indicated that they would like to. Unfortunately, the training given Ceylon's teachers did not help them at all to recognise the many ecological problems around them.

The tour eventually came to an end. Lying in my berth on the night-train to Colombo I was going over, in my mind, the experiences of the past 3 days, when it suddenly came to me that what I should get started was a long-term hydro-biological survey of the Thondiamannar Lagoon, by teachers and senior students. It would provide teachers and students with joint research, within their ability, which would excite and vitalise their approach to biology (even chemistry and physics and geography); it would provide teachers with field-classes that would not become boring but would increase in interest as the aquatic community was seen to change gradually as the lagoon gradually became a fresh-water lake; it would provide teachers with problems for individual research, for the Survey would force many such on their attention. But perhaps more important than these and the many other benefits it would bring, the Survey would lead to radical changes in the teaching of biology, first in the Jaffna Peninsula and then in the rest of our island.

After I reached Colombo I wrote to the Secretary of the Northern Province Science Teachers' Association (NPSTA), setting out my idea of a Hydrobiological Survey and what it would achieve; and I asked him to persuade the NPSTA to take it up. The Secretary, Mr. V. Ramakrishnan of Jaffna Hindu College, printed the relevant parts of my letter *verbatim*, in a circular, which he sent to members of the NPSTA urging acceptance of my scheme, and which I reproduce below since it contains my arguments in some detail :—

I am quoting below verbatim a portion of a letter I received from Dr. A. Weerakone, Lecturer in Zoology, University of Ceylon. I should thank you if you would kindly go through it and give me your reactions. I should thank you for a reply per return of post as any action we decide to take must be taken quickly.

".....there are no connected accounts available (certainly not for schools, but also not even in research journals) of the life in any of the typical habitats in Ceylon. And when I was in Jaffna last it came to me that a continuous survey of a relatively circunscribed habitat like the Thondaimannar lagoon would be the answer to these problems besides being valuable too in other ways.

"As you know the lagoon is in the early stages of its conversion into a fresh-water lake. Over the years as it gets steadily less salty, its fauna and flora must steadily change.

"My idea is that there should be a co-ordinated survey of the changes in the lagoon by several teams of teachers and students from various Jaffna schools. Each school would be assigned some part of the lagoon, on the study of which they would concentrate. Each year the teachers of that school would take a selected group of his senior students into the field for a few days (more or less in the same season for all schools and for all years) and make a hydrobiological survey of the area assigned that school. This survey would involve mainly the collecting of the animals and plants from that area, the measurement of certain physical and chemical features of the shores and the water — e.g., water-level, salt content, etc. The material brought back to the school would then be examined and identified, as far as possible. For a start rough quantitative estimates of numbers may be all that is necessary. Then each year, on a date to be fixed so as to be convenient to as many as possible of the school-teams concerned, but in any case roughly about the same time each year, all the teams would meet, appoint a chairman from amongst themselves and then proceed

(*a*) to receive the several reports of school-teams, and

(*b*) to organise all the facts into a report on the lagoon for that year.

"This, as I have said, will happen year after year and, to both teachers and students, a living picture of the changing environment and life of the lagoon will soon develop. Within three or four years you all could publish a most interesting interim-report; within 10 or so years a most valuable book on the Thondaimannar lagoon.

"The success of the work will depend entirely on the field-workers, especially the teachers. For all of them zoology will "come alive"; and the teachers will be training themselves in research and actually doing research themselves. And zoology in Jaffna, and indeed in the whole of Ceylon, will be assisted forward very considerably. Indeed the whole scheme could become a wonderful recruiting ground for our future research-workers.

"I come in only at the start — to set out the overall plan for you all; and later on, of course, for any help you may require to make contacts with taxonomists abroad for the purpose of helping with identifying your collections; and for any advice you may seek. But the work will essentially be yours. It will be a big job and wonderfully worth doing and also one which you all *can do*.

"..... the next step will be for me to pay a very short visit to Jaffna and explain to all those teachers interested, at a meeting, the plan in some detail; set forth what it will entail in time, in expenses (relatively little); what if should achieve; what simple collecting implements, etc., will be required.

"An organising committee might be left to make the necessary preliminary arrangements. When these are completed I could come along again and help with the first collecting trips — with the purpose of giving the teachers some idea of the sort of thing they will have to get their teams of school children to do. (This second trip only if you all require it.)

"I shall be grateful if you helped with the arrangements at that end — that is, of course, if you are still interested ..... With my sincere regards, yours faithfully, Arthur Weerakone.

"*P.S.* I shall probably be leaving the island in September for a year or so. So any trips to Jaffna will have to be well before that. A.W."

With that the Secretary ended his quotation of my letter; and he went to state his own reactions to my proposal and concluded with the following paragraph : If you are willing to co-operate, please write to me immediately. I will in my personal capacity call a meeting on 11th July 1959 at 9.30 a.m. somewhere in town; and request Dr. A. Weerakone to meet us on that day to organise and assign work to us. Thanks. Yours faithfully, V. Ramakrishnan.

At that 11th of July meeting in Jaffna I explained to the many teachers and school Heads present, what a hydrobiological survey of the lagoon would involve, what its aims were and what its benefits were likely to be. I ended by warning that, because changes in the environment would not be *easily* recognisable in the first few years of the survey, interest in the novelty of the first year's work was likely to flag in the next year or two; and I assured the teachers that if they stuck to it through that period they'd be certain of success.

My proposal was adopted. I discussed equipment with a small committee, which undertook to collect or get made what was needed (according to a written summary to be sent by me). I next inspected the lagoon and decided on certain characteristic habitats which had to be worked, the committee undertaking to assign schools to them. It was decided that I was to visit Jaffna again, once the equipment was ready, to demonstrate special collecting methods and analyses (e.g., for dissolved Oxygen).

This next journey too I made (15th-17th August), taking an Assistant Lecturer[10] from the university to provide myself with an extra pair of hands—for, 27 schools had enrolled for the project and therefore a large number of teachers would be attending. My talks and demonstrations were given; the teachers tried the methods for themselves; and the Survey was launched. I left the island soon after for a year, but contributed nothing further to the project even on my return. Its subsequent achievements have been due to :—

(i) the seminal nature of the original ideas and the confidence — generating nature of work on the project; and

(ii) the enthusiasm and hard work of the many teachers from schools of the Peninsula who have dedicated themselves to it.

As I had predicted, interest flagged after the first year (1960). In addition the Survey had to contend with disturbances in the schools' organisation following upon their Take-over and with the final return to India of the NPSTA Secretary who had been so enthusiastic a supporter. Nevertheless, some teachers stuck it out and kept the project alive; and in about 2 years, one of them emerged as another energetic co-ordinator[11] of the Survey. By 1965 he and the other teachers involved had developed it to such an extent that the Survey began to have many important side-effects.

It improved the teaching in schools; it stimulated, in students and teachers, initiative and an interest in science and its application to their own every-day world and its problems, hence an interest in research; it recruited several persons into research careers; it led to the NPSTA's setting up, in 1968, a Field Work Centre[12] at Thondaimannaru, the first of its kind in Ceylon. All this in addition to the valuable scientific results of the Survey, which included substantial studies of the mangroves, the fishes, and the prawns of the lagoon; and suggestions for an increase in its fish-productivity.

Nor were the side-effects confined to Jaffna; they overflowed, as I had predicted they would, into the south of our island, and led, amongst other things to the establishment by the Education Ministry in 1976 of a Field Work Centre in Peradeniya for teacher training; and in 1979 of one at Kurulukele in Kegalle for studies of forest ecology by teachers and students; and shortly after that of yet another at Naragala near Horana in the flood plain of the Kalu Ganga also for studies by teachers and students.

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10. Dr. C. H. Fernando.
11. Mr. M. Atputhanathan, then a teacher of Hartley College, Point Pedro, who later, in 1968, first voiced the need to set up a Field Work Centre to continue and build on the achievements of the Survey.
12. Accounts of the subsequent activities at this Centre and of its influence on science education in Ceylon are to be found in several papers in FWC. Newsletter, Vol. ix, No 2, 1978. It should be noted however that the statements in them as to the conception and early history of the Hydrobiological Survey of the Thondaimannar Lagoon are, some partly some wholely, incorrect, as this present paper clearly shows.

It is now only a matter of time before the growing realisation, that field research and field centres play an immensely valuable role in education, persuades the central authorities controlling university education to react less discouragingly than they have hitherto done to attempts by university departments of biology to have *their own* Field Stations for field studies and field research.

III. CONCLUSION

Accounts are given of 3 successful attempts to use research by pre-graduate students as an educational tool, two of them at Vidyodaya (now, Sri Jayewardenepura) University, and the third in schools.

In all these attempts the acquisition of biological knowledge by the student was only one of several important aims. Even more important than this (particularly in the context of a Third World, ex-colonial, country) were certain others, like the instilling of self-confidence and self-reliance, the encouragement of initiative and the use of observation and experiment, especially in the field.

The account of the attempt for schools has inevitably included a history of the earliest beginnings of co-ordinated field-studies by schools, namely the Tondaimannar Lagoon Hydrobiological Survey; which is of interest since this Survey has led (i) to considerable and valuable changes of approach to the teaching and learning of science in the island's schools, including the introduction and use of Field Study Centres (of which there are now four); and (ii) to school teachers' taking up scientific research, with a resultant improvement in their quality as teachers of science.